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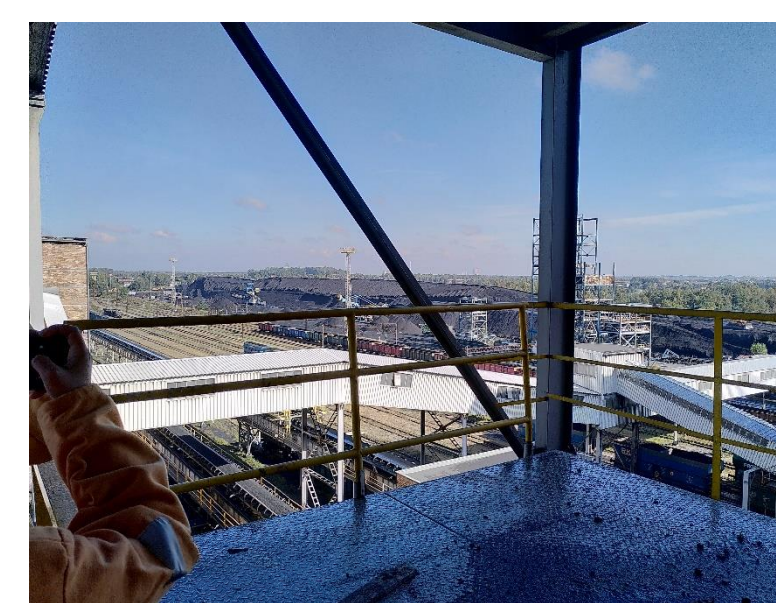
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Assessing the potential environmental and economic benefits of coal mining wastes upcycling into concrete products



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Solid fossil fuels still have a share of 12,4% in the European Union energy mix. In Poland, this share even reached 43% in 2021 (Eurostat 2023). Extracting and producing coal leads to the generation of coal mining wastes (CMW) that lead to additional costs for the mine operators as well as to environmental burdens. One option for reducing these costs is to use these CMW as secondary raw materials for the construction sector. The overall goal of this study is to assess the potential environmental and economic benefits of using these CMW as constituents for concrete panels.



CMW stockpiling © BRGM

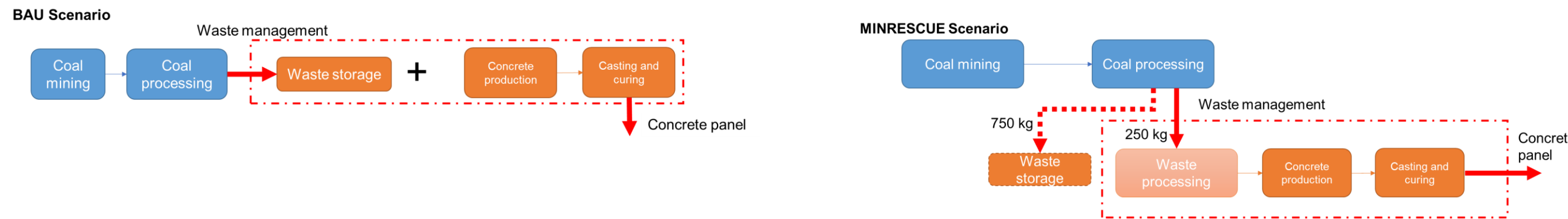


Concrete panels © Nuova Tesi

Methodology and data collection

The business as usual (BAU) scenario is compared to three recycling scenarios where CMW replace sand and gravel in the concrete mix to produce concrete panels. Each recycling scenario corresponds to a different concrete mix, in which the share of CMW varies as a function of its granulometry.

Functional unit: The management of 1 ton of solid wastes from coal processing and the production of 1 pre-cast concrete panel.



Life cycle assessment

ecoinvent v. 3.7, SmaPro v. 9.4, EF 3.0

Cost benefits assessment considering externalities

Internalize externalities using monetizing factors from the MODEXT¹ database. MODEXT was chosen for its geographical coverage, the coverage of environmental impacts and being relatively recent.

- Using LCI et LCIA results from the LCA
- Adapting monetizing factors to express results in €₂₀₂₂ by taking into account inflation

Main data sources

- Industrial data (mine operator, concrete panel producer)
- Experimental data for long-term emissions due to CMW storage
- Databases and technical reports
 - ecoinvent database
 - CostMine
 - Eurostat, Polish statistical institute
 - Comité National Routier (in French)

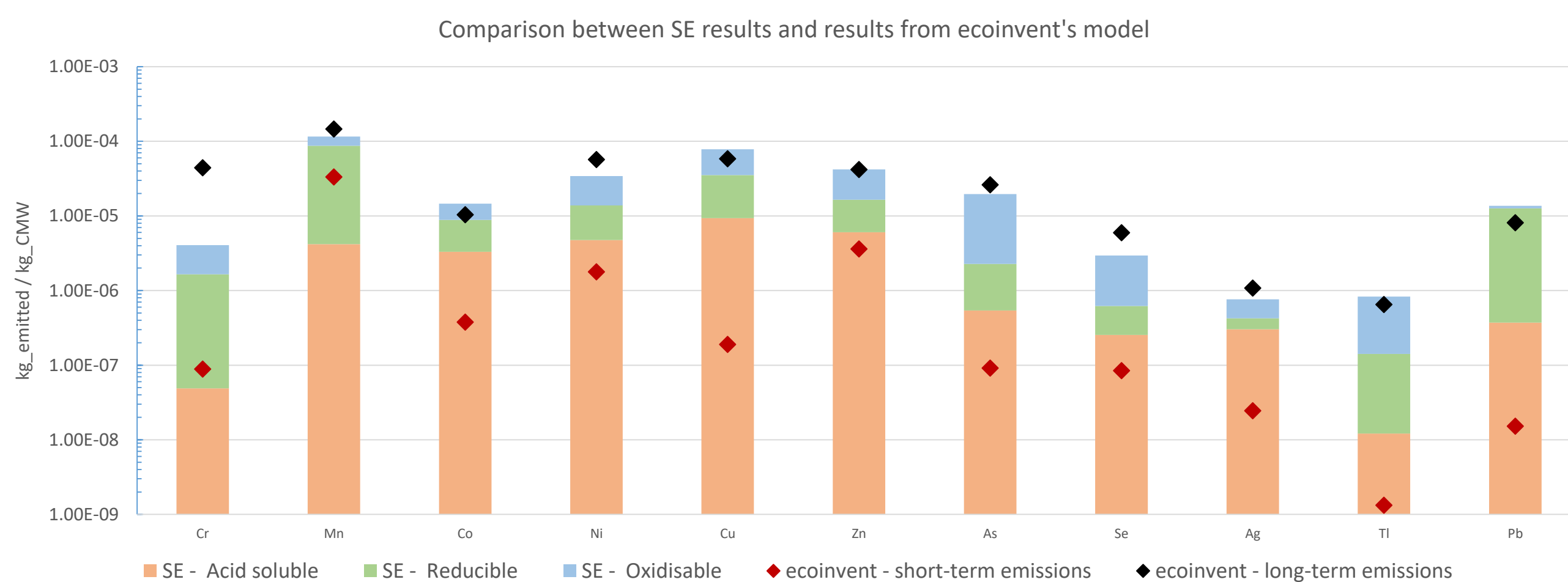
Emissions due to CMW storage

To estimate the long-term emissions associated with the presence of the waste storage area, initial composition of the wastes as well as experimental data from **sequential extraction** are used and results are compared with the ones from ecoinvent's model.

Sequential extraction (SE)²: analytical method that leads to the determination of the fraction of an element present in the waste that could be leached out considering three mechanisms (acid soluble, reducible, oxidisable).

ecoinvent's model: model derived from the landfill model developed by G.Doka³, it is based on a first order kinetic model that does not consider all physical and chemical interactions occurring.

In this study, model adapted to consider CMW composition and geographical context.



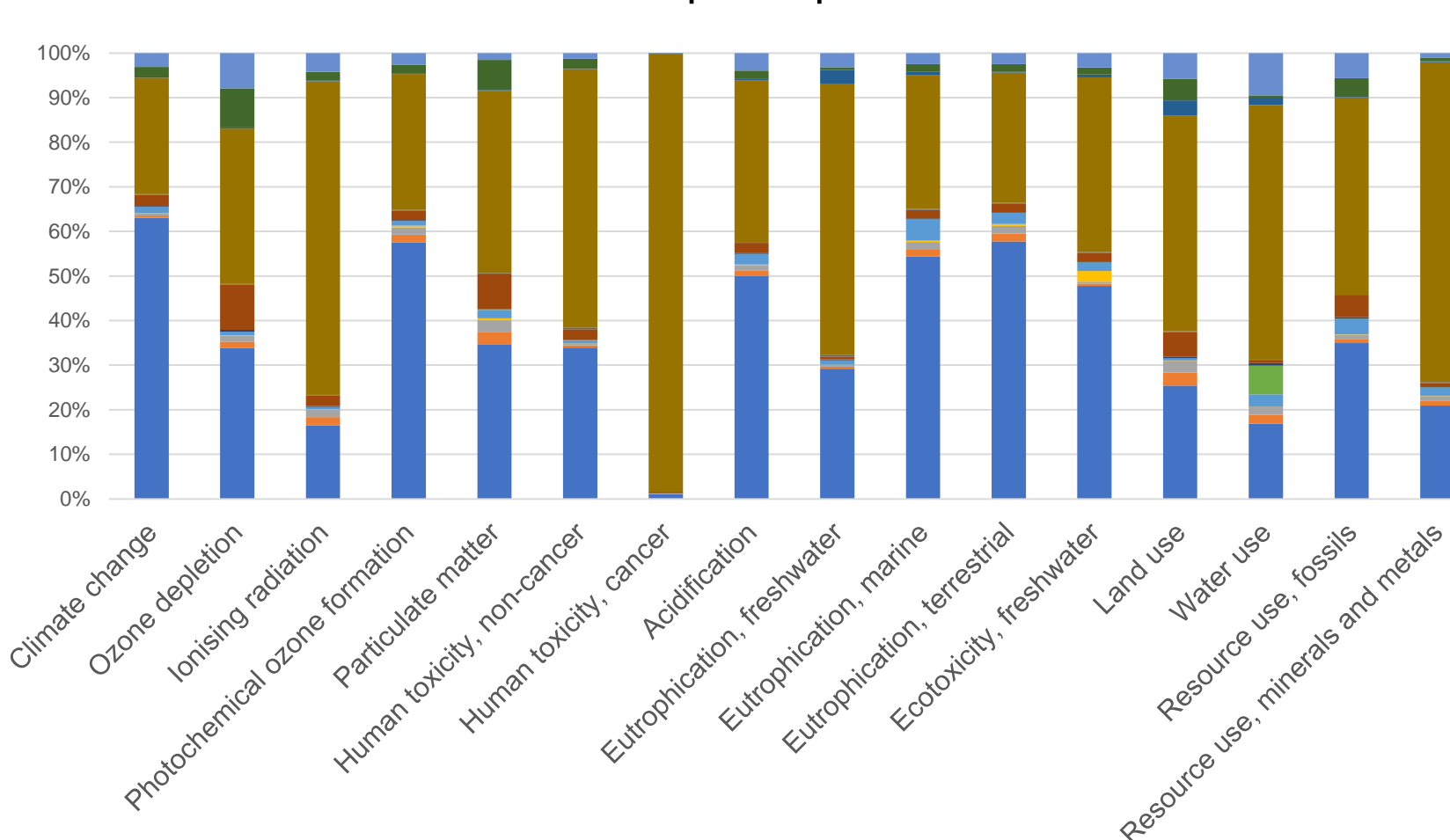
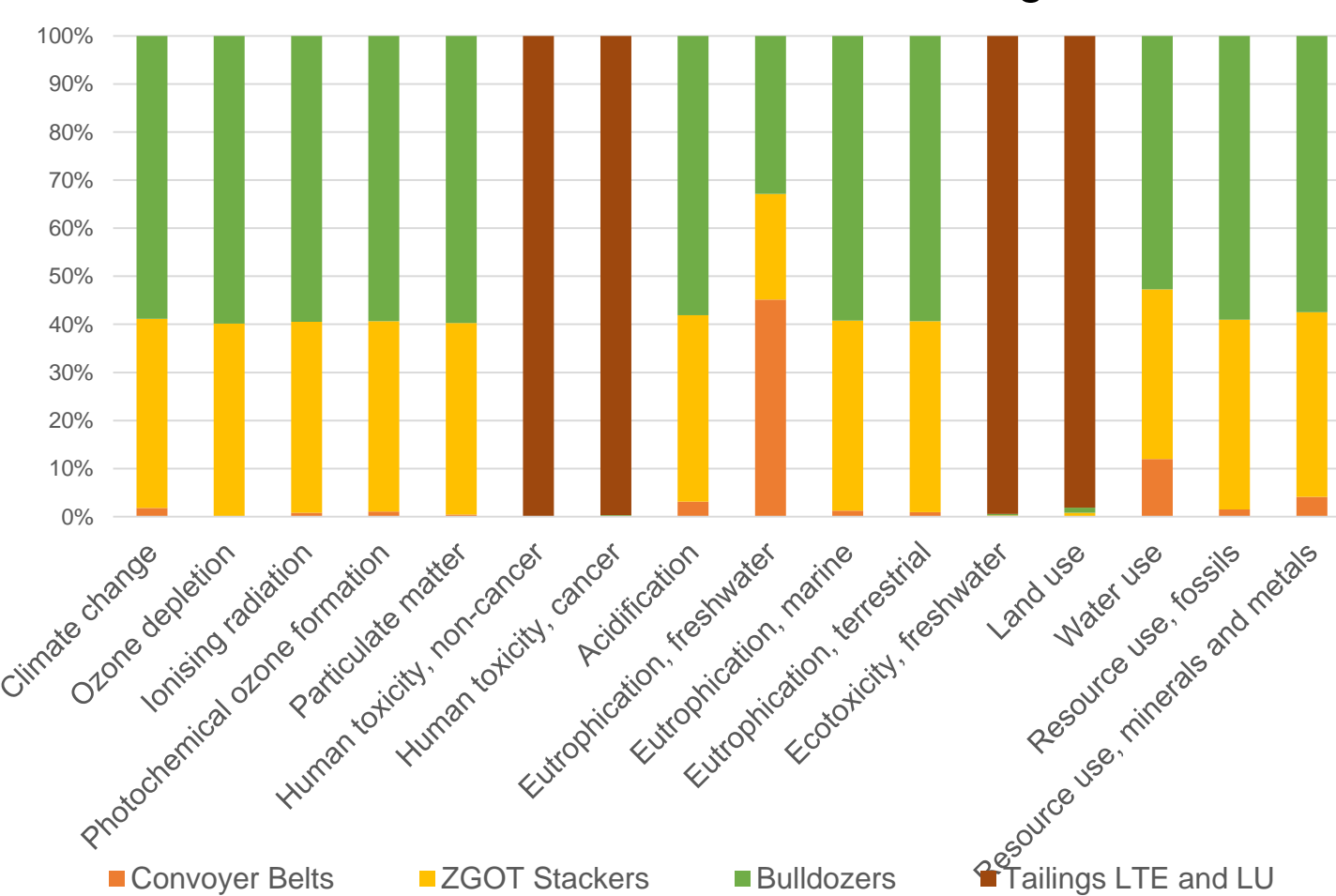
- Where SE results represent a maximum value that is potentially leached out, in ecoinvent's model, results are time-dependant
- SE results consider potential physico-chemical interactions that might occur in the waste storage area
- ecoinvent's model might overestimate emissions for some elements (Cr, Cu, Pb) that are even more characterized

Results

Life cycle assessment

BAU scenario results : coal wastes management

BAU scenario results: concrete panel production



- Impacts are driven by the diesel consumption of machinery except for toxicity and ecotoxicity impacts driven by the long-term emissions associated to CMW

- Cement and steel production account for the largest share of the impacts

Cost benefits assessment

	BAU	MINRESQUE_1	MINRESQUE_2	MINRESQUE_3
Cost per FU (€_2022)	54 602.59 €	58 434.94 €	58 746.56 €	58 654.48 €
CAPEX	7.85 €	7.84 €	7.84 €	7.84 €
OPEX	532.23 €	687.72 €	711.60 €	619.52 €
Environmental costs	54 062.52 €	57 739.49 €	58 027.24 €	58 027.24 €
	99.01%	98.81%	98.78%	98.93%

- Costs are driven by the environmental externalities
- Costs of environmental externalities are driven by the climate change impact (both in terms of monetizing factor and value of the impact)
- Except for CAPEX, the OPEX and environmental costs are higher for the MINRESQUE recycling scenarios than for the business-as-usual scenario

Conclusions and perspectives

Overall, limited benefits on environmental impacts – as CMW replace sand and aggregates - that reflects on the economic evaluation where costs are driven by externalities

Comparison done on hypothetical scenarios need to be adapted to consider *real* business models (e.g. consideration of CMW transportation)

Traditional LCA fails to capture the benefits of keeping natural resources (here coal processing wastes) into the anthroposphere

- Potential benefits regarding circularity of materials
- Potential benefits to overcome local pressure on the sand and aggregates markets of some regions

MINRESQUE solutions attenuate the undesirable local effects of the presence of a waste storage area on the landscape and on the local environment (associated with toxicity and ecotoxicity impacts)

References

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